AD-A085 567 DAVID W TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CE--ETC F/G 13/10
SWATH 6D MODEL EXPERIMENTS IN REGULAR HEAD AND FOLLOWING WAVES --ETC(U)
FEB 80 J A KALLIO
UNCLASSIFIED DTNSRDC/SPD-0914-01 NL

1 OF 1
AD A
085567

END
DATE
FILMED
7-80
DTIC

DTNSRDC/SPD-0914-01

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

AD A085567

SWATH 6D MODEL EXPERIMENTS IN REGULAR HEAD AND FOLLOWING WAVES WITH AND WITHOUT FLOODABLE STRUTS

by

JAMES A. KALLIO

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

MAY 27 1980

A

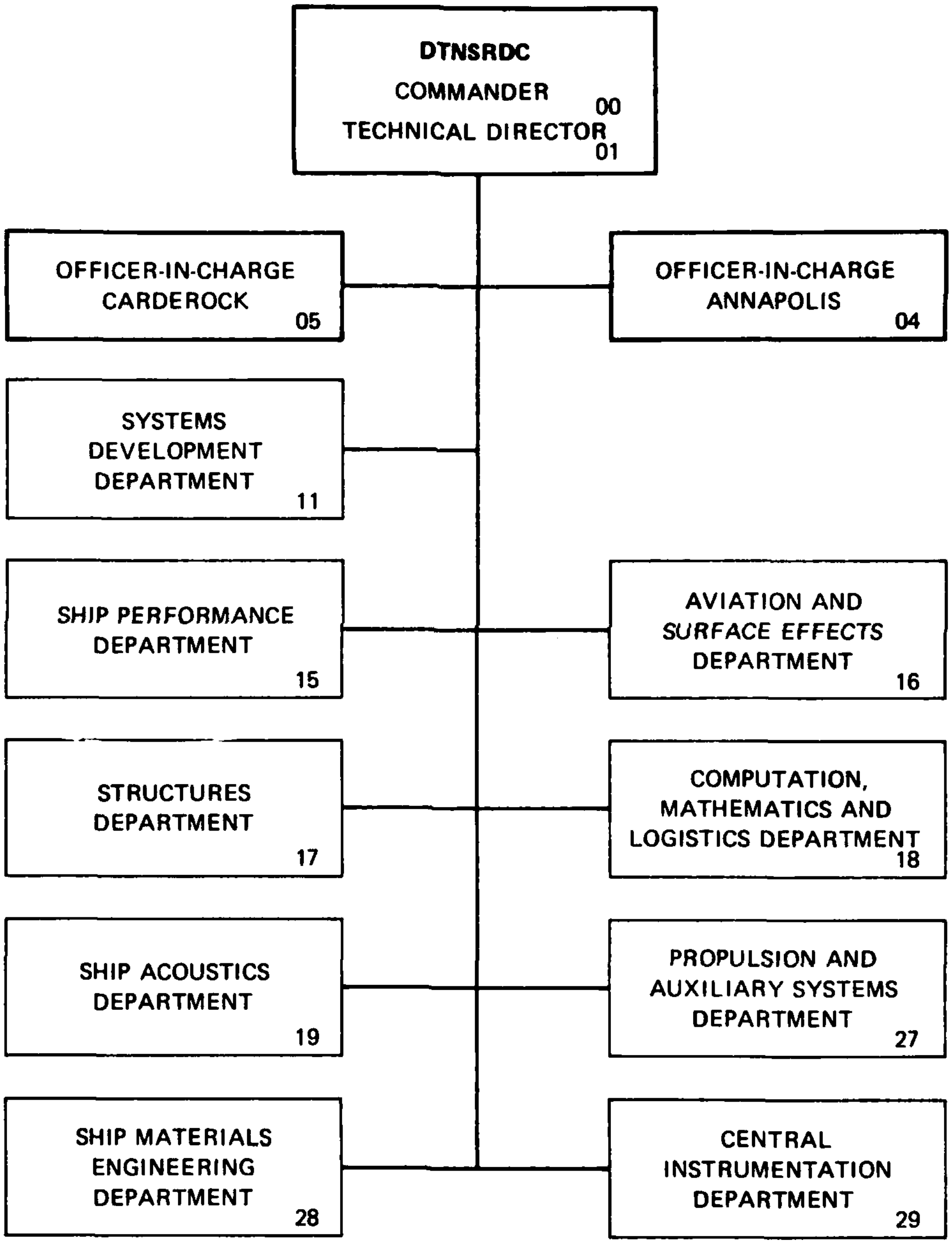
SHIP PERFORMANCE DEPARTMENT

FEBRUARY 1980 DTNSRDC/SPD-0914-01

SWATH 6D MODEL EXPERIMENTS IN REGULAR HEAD AND FOLLOWING WAVES WITH AND WITHOUT FLOODABLE STRUTS

80 5 23 006

MAJOR DTNSRDC ORGANIZATIONAL COMPONENTS



UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER (14) DTNSRDC/SPD-Ø914-Ø1	2. GOVT ACCESSION NO. AD-A085567	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) (6) SWATH 6D MODEL EXPERIMENTS IN REGULAR HEAD AND FOLLOWING WAVES WITH AND WITHOUT FLOODABLE STRUTS.		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) (10) JAMES A./KALLIO		8. CONTRACT OR GRANT NUMBER(s) (11) Feb 80
9. PERFORMING ORGANIZATION NAME AND ADDRESS David W. Taylor Naval Ship R&D Center Ship Performance Department Bethesda, MD 20084		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Work Unit #1100-200
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Sea Systems Command Washington, DC (12) 41		12. REPORT DATE ~~September 1979~~
		13. NUMBER OF PAGES 37
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(16) F43411

SF43411121

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

SWATH Motions and Accelerations, Head and Following Regular Waves, Intact and Flooded Struts, Tandem Strut Configuration

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Experiments were conducted with a model of a tandem strut small waterplane area twin hull ship in the Carriage II Facility of the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) to determine motions and accelerations at various speeds and two headings. Data were obtained in regular waves for model configurations with the struts intact and for the struts with 40% of the waterplane area flooded. Experimental results are compared with those for previously tested strut configurations

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-014-6601

i

UNCLASSIFIED 389694

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

with the same model lower hulls. Pitch and relative bow motions for the intact strut configuration decrease dramatically in head seas as speed increases up to 28 knots. Flooding about 40% of strut waterplane area resulted in a large increase in natural heave, pitch and roll periods and a decrease in pitch, relative bow and vertical motions for the craft operating in head seas at up to 20 knot speeds.

TABLE OF CONTENTS

ABSTRACT 1

ADMINISTRATIVE INFORMATION 1

INTRODUCTION 1

DESCRIPTION OF MODEL AND EXPERIMENTAL EQUIPMENT. 2

DESCRIPTION OF MEASUREMENTS AND INSTRUMENTATION. 3

EXPERIMENTAL PROCEDURE 4

DATA COLLECTION AND REDUCTION. 4

PRESENTATION AND DISCUSSION OF RESULTS 5

CALM WATER. 5

REGULAR WAVES 5

CONCLUSIONS AND RECOMMENDATIONS. 10

REFERENCES 13

LIST OF FIGURES

1 - Sketch of SWATH 6 Strut Configurations A, B, & C 14

1b - Sketch of SWATH 6D Strut Configuration 15

1c - Sketch of SWATH 6D Floodable Strut Section Locations 16

2 - Fin Size, Shape and Location on SWATH 6. 17

3 - Motion Transfer Functions in Regular Head Seas for SWATH 6D with Struts Intact. 18

4 - Motion Transfer Functions in Regular Head Seas for SWATH 6D with Struts Flooded 19

5 - Motion Transfer Functions in Regular Head Seas for SWATH 6C 20

6 - Vertical Displacement Transfer Functions in Regular Head Seas for SWATH 6D with Struts Intact. 21

7 - Vertical Displacement Transfer Functions in Regular Head Seas for SWATH 6D with Struts Flooded 22

LIST OF FIGURES (CONT)

8 - Vertical Displacement Transfer Functions in Regular Head Seas for SWATH 6C 23

9 - Motion Transfer Functions in Regular Following Seas for SWATH 6D with Struts Intact. 24

10 - Motion Transfer Functions in Regular Following Seas for SWATH 6D with Struts Flooded 25

11 - Vertical Displacement Transfer Functions in Regular Following Seas for SWATH 6D with Struts Intact 26

12 - Vertical Displacement Transfer Functions in Regular Following Seas for SWATH 6D with Struts Flooded. 27

13 - Motion Transfer Functions in Regular Following Seas for SWATH 6 - 20 Knots. 28

LIST OF TABLES

1 - SWATH 6 Craft Particulars. 29

2 - Transducer Locations on SWATH 6D 31

3 - SWATH 6D Regular Wave Experiment Matrix. 32

4 - SWATH 6D Natural Periods in Calm Water 33

5 - Definition of SWATH 6 Transfer Functions 34

ABSTRACT

Experiments were conducted with a model of a tandem strut, small waterplane area, twin hull ship in the Carriage II Facility of the David W. Taylor Naval Ship Research and Development Center (DTNSRDC) to determine motions and accelerations at various speeds and two headings. Data were obtained in regular waves for model configurations with the struts intact and for the struts with 40% of the waterplane area flooded. Experimental results are compared with those for previously tested strut configurations with the same model lower hulls. Pitch and relative bow motions for the intact strut configuration decrease dramatically in head seas as speed increases up to 28 knots. Flooding about 40% of strut waterplane area resulted in a large increase in natural heave, pitch and roll periods; and a decrease in pitch, relative bow and vertical motions for the craft operating in head seas at up to 20 knot speeds.

ADMINISTRATIVE INFORMATION

The work described herein was performed for the Small Waterplane Area Twin Hull (SWATH) Ship Development Office (Code 1110) in the Systems Development Office of DTNSRDC. Funding was provided by work unit no. 1100-200. The funding source was the SWATH Ship Exploratory Development Program, under the Ships, Subs, and Boats Program Task Area SF 43411211, Task 19424. The Program Manager was Mr. Schuler, Code 031R, of the Naval Sea Systems Command, Washington, DC.

INTRODUCTION

An experimental seakeeping program was conducted with a model of a small waterplane area, twin hull (SWATH) ship with a tandem strut configuration represented by a 1:22.5 scale model, designated as SWATH 6D. Experiments were conducted in head and following regular seaways at speeds corresponding to full scale speeds of 0, 4, 10, 20, and 28 knots. Calm water experiments were also conducted at these speeds. These experiments were conducted with the model free running without restraint, in six

degrees of freedom. Measurements were made of the seaway; the craft pitch, roll, yaw, heave, surge. sway, relative motion near the bow, as well as vertical acceleration at three places along the craft length; and the stern horizontal fin angle. Investigations were made of the effect of flooding 40% of the strut waterplane area on craft motions and accelerations in regular head and following seas. This report presents motion transfer functions determined from regular wave experiments. These transfer functions are compared with the results of experiments conducted on the same model with different strut configurations as reported in Reference 1*.

DESCRIPTION OF MODEL AND EXPERIMENTAL EQUIPMENT

The model used in this investigation was a 1:22.5 scale model, DTNSRDC Model 5337, of a 2900 ton developmental SWATH type craft designated as SWATH 6D. A new set of tandem struts was constructed for this model, though the lower hulls are the same ones used for previous SWATH 6 experiments. This set of struts was constructed of fiberglass such that 40% of the waterplane area of each strut could be free flooding or be tested intact. Craft particulars for the two strut configurations of the SWATH 6D, and craft particulars for the three previous strut configurations are presented in Table 1.

The major difference in characteristics imparted to the craft by the different strut configurations is the longitudinal $\overline{GM}$. Figure 1a shows the physical dimensions for the first three different craft configurations while Figures 1b and 1c show the physical dimensions for the 6D configuration. Note that while SWATH 6A and 6B have only one strut per hull, 6C and 6D have two struts per hull. Also note (Figure 2) that all

*References listed on Page 13.

configurations used a set of horizontal stabilizer fins (two per hull, inboard) and those for 6A and 6D had about 40% greater projected area than those used on configurations 6B and 6C. Fin shape and size are shown in Figure 2. The forward fins on all configurations were fixed at zero angle of attack while the angle of attack on the aft set was variable and could be changed by means of a remotely controlled actuator.

The port and starboard hull-strut combinations were attached to each other by a rigid bridging structure.

Propulsion was provided by two five horsepower D.C. motors, one housed in each hull. Since the model was free running, controllable rudders were used to maintain course.

DESCRIPTION OF MEASUREMENTS AND INSTRUMENTATION

The SWATH 6D experiments were conducted with the model self propelled and free running. Tether lines, required for acceleration and deceleration of the model, and motor power cables and transducer signal cables were the only connections between the model and carriage. These lines and cables were slack during data collection and did not affect model responses. Model speed was controlled manually and was regulated in accordance with preset carriage speed. Thus the model was kept fairly stationary with respect to the carriage, and model speed was relatively constant. However, during some head sea conditions with severe impacting, and during some following sea conditions, there was considerable surge motion and the tether lines become taut at times.

Course was maintained by means of yaw and sway signal inputs to the rudder servo control device. Heave, surge, sway and relative motion at the bow as well as wave height were measured by ultrasonic displacement

transducers. Heave was measured at the longitudinal center of gravity (LCG) on the centerline, surge at the aft edge of the bridging structure, and relative bow motion 9 ft (2.8 m) forward of the front edge of the bridging structure, on the centerline.

Pitch, roll, and yaw were measured by gyroscopes mounted near the LCG just to port of the centerline. Vertical accelerations were measured at the bow, at the LCG and at the stern on the centerline at the locations indicated in Table 2.

EXPERIMENTAL PROCEDURE

Experiments were conducted with the struts intact as well as partially free flooding, in calm water and in regular head and following seas. Calm water experiments were conducted at 0, 4, 10 and 20 knots (full scale) to determine running trim and sinkage for various stern fin angles with struts intact. During all experiments, the forward fins were fixed at zero angle of attack. Stern fin angles which produced a near zero running trim for each particular speed were not excessively large (about 2.5 to 3.0 degrees trailing edge up).

Once the trim moments and fin angles were established, calm water runs were conducted during which the model was force pulsed manually near its natural frequency in pitch, heave or roll at the various speeds in order to determine motion decay curves and natural periods. In cases at the 28 knot (full scale) speed, the motion was so highly damped that determination of the natural heave and pitch period was impossible by this method. Determination of natural periods for the flooded strut configuration was done at zero speed only.

Experiments were then conducted in regular waves at the headings and speeds indicated in Table 3. Nominal wave steepness, defined as twice

the wave amplitude divided by the wave length ($2\zeta_A/\lambda$), for the regular wave experiments ranged from about 1/50 to 1/90.

DATA COLLECTION AND REDUCTION

During the experiments, the transducer signals were amplified and recorded in analog form on paper strip chart and analog magnetic tape.

Calm water and regular wave data were recorded and analyzed by the Interdata 70 on the carriage, providing immediate experimental results. Natural period oscillation data were read from strip chart records.

Reduction of regular wave data by the Interdata 70 provided motion amplitudes, phases, mean offsets, amplitudes at the first harmonic wave frequency, and the transfer function for each particular measurement. The immediate availability of this data on the carriage facilitated planning of future run conditions as the experimental program proceeded.

Absolute vertical motions at the bow, the LCG and at the stern were obtained by integrating the vertical accelerations at these respective locations.

PRESENTATION AND DISCUSSION OF RESULTS

CALM WATER

Calm water experiments were conducted on the SWATH 6D configuration with struts both intact and partially flooded at 0, 4, 10, and 20 knots full scale. No vertical plane instability was revealed during any of these experiments. Heave, pitch and roll natural periods for the intact strut configuration at 0, 4, 10, and 20 knots and for the flooded strut configuration at zero speed are presented in Table 4.

REGULAR WAVES

The regular wave data in this report are presented as a function of

wave length, and the motions nondimensionalized as transfer functions in accordance with the scheme shown in Table 5. The observations made during the discussion of regular wave data refer to the maximum dimensionless response and not to the response to any particular wave length. Vertical acceleration data are not nondimensionlized. However, dimensionless absolute vertical motions were calculated from the vertical accelerations (see Figure 5), and they give an indication of a transfer function type relationship for vertical acceleration.

Results of experiments conducted in regular head seas are presented in Figures 3 through 8. Figure 3 presents pitch, heave and relative bow motion (RBM) transfer functions for the craft operating in regular head seas with the struts intact. Maximum dimensionless pitch and RBM both decrease as speed increases from zero to 28 knots. At 4 knots the RBM value of less than unity for wave lengths greater than 775 ft (236 m) indicates a contouring type of motion. At 10 knots contouring occurs in waves longer than 1000 ft (305 m). Maximum dimensionless heave is about the same at 0 and 4 knots and increases as speed increases to 10 knots where it remains about the same through 28 knots.

Figure 4 presents results of experiments in regular head seas at 4, 10 and 20 knots with the struts flooded. Maximum dimensionless heave, pitch and RBM are greatest at 4 knots in wave lengths longer than 900 ft (274 m). There is little difference in the responses at 10 and 20 knots. Comparing Figures 3 and 4, the maximum dimensionless pitch and relative bow motions are significantly lower for the craft configuration with the struts flooded at 4, 10 and 20 knots in wave lengths shorter than 750 ft (229 m). Maximum dimensionless heave for the flooded strut configuration

is greater than for the intact configuration in wave lengths longer than 900 ft (274 m) at 4 knots but is the same or less in all wave lengths at 10 and 20 knots. The decrease in pitch and RBM is partly due to the increase in pitch natural period for the flooded configuration (see Table 4). Another contributing factor is that the ship in the flooded configuration rode about 7.8 ft (2.38 m) deeper than with struts intact (see Reference 2). The draft was deeper in the flooded configuration because there was no ballast weight which could be removed to compensate for the loss in buoyancy.

Figure 5 (from Reference 1) presents dimensionless pitch, heave and RBM for the SWATH 6C tandem strut configuration. Comparing Figure 3 with Figure 5, the maximum dimensionless pitch and RBM at 0 speed is less for the 6C configuration than the 6D configuration but for 6C the pitch response curve is double peaked while for 6D there is only one peak. Maximum dimensionless pitch at 20 and 28 knots is about the same for both 6C and 6D configurations. Maximum dimensionless heave at 20 and 28 knots is about the same for the 6C and 6D, but at 0 speed the 6D configuration has less heave in wave lengths around 450 feet (137 m). Maximum dimensionless RBM at 0 speed is greater for the 6D than the 6C, but for 6D the RBM response decreases to less than unity in waves longer than 620 ft (189 m) while for 6C this occurs only in waves longer than 900 ft (274 m). At 20 knots the maximum dimensionless RBM is greater for the 6C while at 28 knots it is about the same for the two configurations.

Figure 6 presents bow, LCG, and stern dimensionless vertical displacement as a function of wave length for the 6D craft in regular head seas with the struts intact. The bow dimensionless vertical displacement

is greatest at 0 speed and decreases as speed increases to 28 knots. Maximum dimensionless LCG vertical displacement (heave) follows the trends noted above for heave obtained by the ultrasonic probe. The maximum dimensionless vertical displacement at the stern is about the same at 0,4, and 10 knots and decreases slightly as speed increases to 20 and 28 knots. At 0,4, and 10 knots the maximum dimensionless vertical displacement is at the bow while at 20 and 28 knots the maximum vertical displacements are about the same at the bow and stern.

Figure 7 presents bow, LCG, and stern dimensionless vertical displacement in regular head seas for the flooded strut configuration. The maximum dimensionless displacements are greatest at 4 knots in long waves and decrease as speed increases to 20 knots. At 4 knots the maximum dimensionless vertical displacement is greatest at the bow while at 10 and 20 knots the maximum dimensionless vertical displacements are about the same at the three locations.

Comparing Figures 6 and 7 the maximum dimensionless vertical displacements are less for the flooded configuration than for the intact configurations except at the LCG location at 4 knots in long waves where the opposite is true.

Figure 8 (from Reference 1) presents dimensionless vertical displacements for the SWATH 6C tandem strut configuration. Comparing Figure 6 with Figure 8, the maximum dimensionless bow and stern displacement at 0 knots is greater for configuration 6D than for 6C while the opposite is true at 28 knots. At 20 knots the bow and stern maximum dimensionless displacements are about the same for 6C and 6D. The LCG maximum dimensionless displacement at zero speed is about the same for both 6C and 6D while at

20 and 28 knots the maximum LCG displacement for 6C is greater than that for 6D.

Results of experiments conducted in regular following seas at 4, 10 and 20 knots are presented in Figures 9 through 12. Pertinent to this discussion is the behavior of the craft in following seas, especially at 20 knots, and the attendant difficulties in obtaining usable data from a tethered model. Because of the large surge excursions experienced by SWATH type craft in following seas due to the long encounter periods, it was difficult to keep the surging model from exceeding the slack in the tether lines and instrumentation cables. Attempts were made to control the surge motion by manually controlling the model power during experiments at 20 knots. This technique may be quite unrealistic because a sudden increase in motor power to keep the craft from surging aftward would make the bow rise sharply, thus debasing pitch and relative bow motion and bow acceleration data. The data presented are from portions of the experimental runs during which model power was fairly constant. Figure 9 presents dimensionless pitch, heave and RBM for the 6D configuration with the struts intact. Maximum dimensionless heave and pitch decrease as the speed increases from 4 to 10 knots while maximum dimensionless RBM is about the same for all three speeds. Comparison of Figures 3 and 9 indicates that maximum dimensionless pitch and RBM are less in following seas than head seas at 4 and 10 knots. Heave is also less in following seas at 10 and 20 knots but about the same for both headings at 4 knots.

Figure 10 presents dimensionless pitch, heave, and RBM for the 6D craft with the struts partially flooded operating in regular following seas at 4, 10, and 20 knots. Maximum dimensionless heave is about the same at all three speeds while maximum dimensionless pitch increases as

speed increases from 4 to 10 knots and RBM increases with speed up to 20 knots. A comparison of Figures 9 and 10 indicates that at 4 knots the maximum dimensionless motions for the flooded strut configuration are less than for the intact strut configuration. At 10 knots the opposite is true except for heave where the maximum dimensionless motions are about the same. The maximum dimensionless motions at 20 knots in following seas are lower for the intact strut configuration.

A comparison of Figures 4 and 10 indicate that for the flooded strut configuration the maximum dimensionless heave at 4 and 10 knots and RBM at 4 knots are larger in head seas than in following seas. These figures also indicate that pitch motion at 4 knots is about the same in both head and following seas while both pitch and RBM at 10 and 20 knots are greater in following than in head seas.

A comparison of Figures 3, 4, 9 and 10 indicates that the lowest maximum dimensionless heave at 4 and 10 knots is experienced in following seas. The lowest maximum nondimensional pitch at 4 and 10 knots occurs in head seas with the struts flooded. The lowest maximum dimensionless RBM at 4 knots occurs in following seas with struts flooded, and at 10 knots it occurs in head seas with the struts flooded.

Figures 11 and 12 present dimensionless vertical motions at the bow, LCG and stern for the 6D craft operating at 4 and 10 knots in following seas with struts intact and flooded, respectively. The maximum dimensionless vertical displacements at the bow and LCG are about the same at 4 and 10 knots whether the struts are intact or flooded. Flooding the struts decreases the maximum dimensionless stern displacement at 4 knots but increases it at 10 knots.

Figure 13 (from Reference 1) presents dimensionless pitch, heave and RBM for the SWATH 6A, B, and C strut configurations in following seas at 20 knots. A comparison of Figures 9 and 13 indicates that at 20 knots in regular following waves the dimensionless pitch response for SWATH 6D with struts intact is lower than for the 6A, 6B, or 6C strut configurations.

CONCLUSIONS AND RECOMMENDATIONS

Results of experiments on a tandem strut SWATH with floodable struts conducted in calm water and in regular head and following seas indicate the following:

1) There were no indications of vertical plane instability for either intact or flooded strut configurations of the SWATH 6D at speeds up to 28 knots.

2) Maximum dimensionless pitch and relative bow motions for the intact strut configuration in head seas decrease dramatically as speed increases up to 28 knots.

3) In head seas contouring motion was observed with the struts intact in waves longer than 775 ft (236 m) at 4 knots, and in waves longer than 1000 ft (305 m) at 10 knots.

4) At 20 knots in regular following waves the dimensionless pitch response for SWATH 6D with struts intact is lower than for the 6A, 6B, or 6C strut configurations.

5) Flooding about 40% of the waterplane area of the struts resulted in a large increase in the natural heave, pitch, and roll periods.

6) Flooding the struts results in a decrease in pitch and relative bow motion in head seas at speeds from 4 through 20 knots.

7) Flooding the struts for head sea operation generally results in a decrease in vertical motions at the bow, LCG, and stern from 4 through 20 knots.

8) Flooding the struts results in a decrease at 4 knots and an increase at 10 knots for the pitch and relative bow motion when the craft is operating in following seas.

9) Surge motions for SWATH craft operating in following seas can become quite severe as noted in Reference 1. The behavior of the SWATH 6D craft with either struts intact or flooded proved no exception to this rule.

It is once again recommended that future experiments in following seas be conducted with a radio controlled model in order to remove the encumbrances of tether lines and transducer cables.

REFERENCES

1. Kallio, James A., "Seaworthiness Characteristics of a 2900 Ton Small Waterplane Area Twin Hull (SWATH)," DTNSRDC Report SPD-620-03, Sept 1976.

2. Kallio, James A. and Ricci, J.J., "Seaworthiness Characteristics of a Small Waterplane Area Twin Hull (SWATH IV) Part I," NSRDC SPD Research and Development Report No. SPD-620-01, August 1975.

SWATH 6

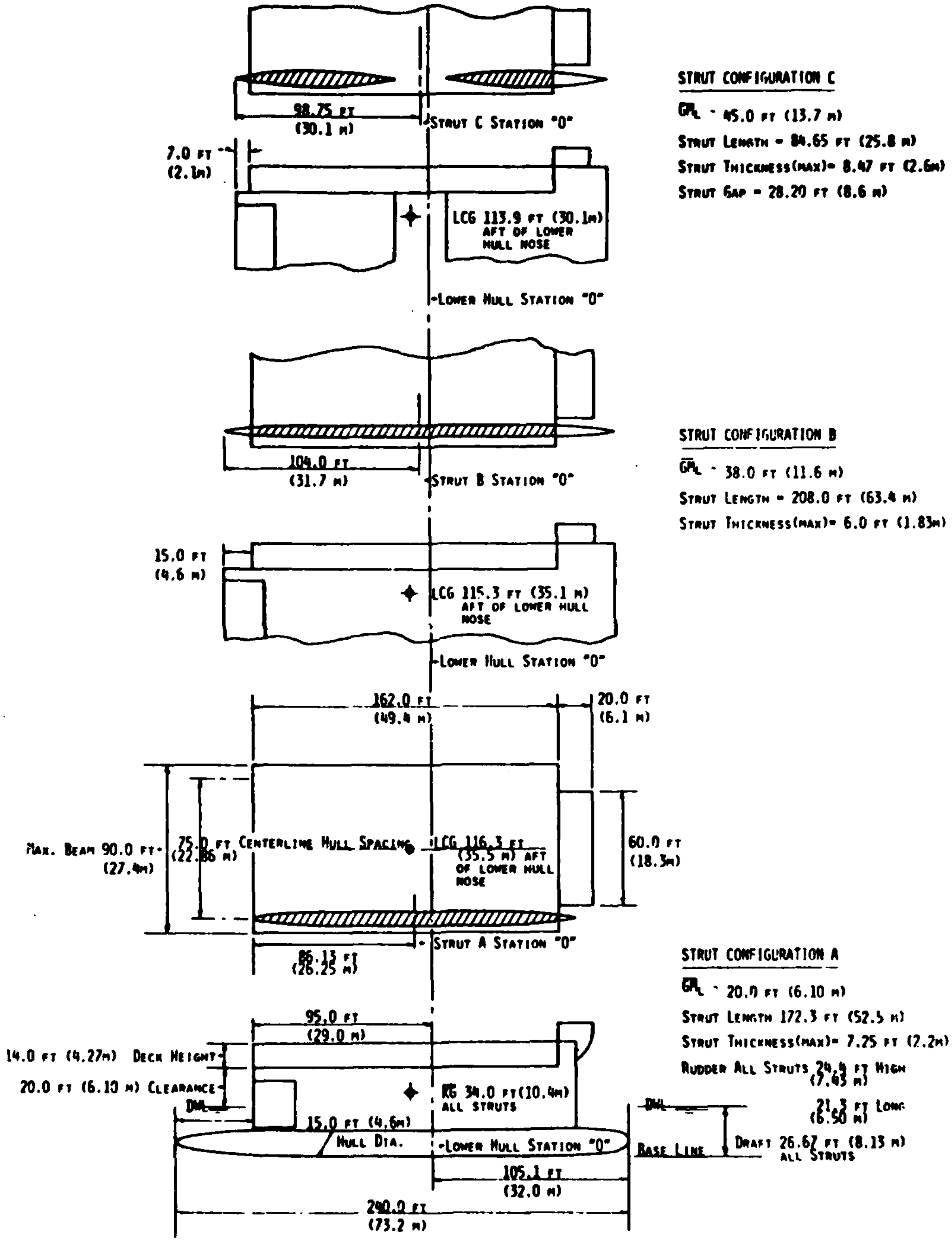
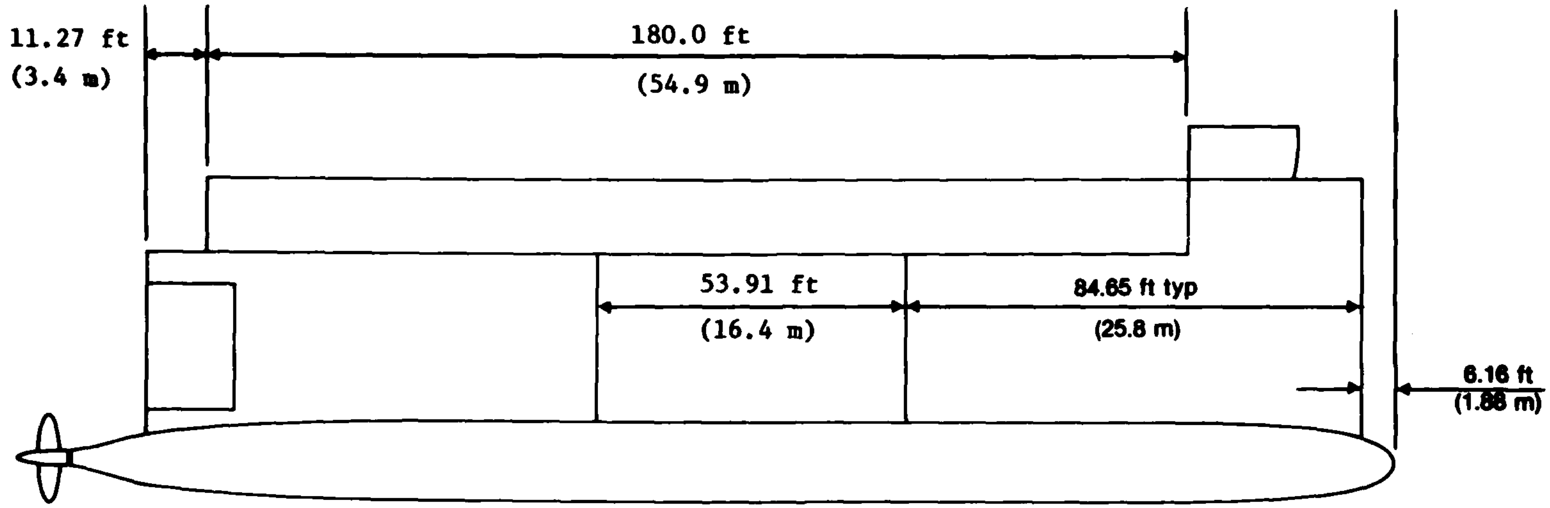


Figure 1a - Sketch of SWATH 6 Strut Configurations A, B & C.



STRUT CONFIGURATION 6D
GM_L (nom) = 86.7 ft (26.4 m)
Strut Length = 84.65 ft (25.8 m)
Strut Thickness (max) = 10.16 ft (3.1 m)
Strut Gap = 40.68 ft (12.4 m)
Deck Width (max) = 97.0 ft (29.6 m)
Rudder 23.6 ft (7.2 m) High
18.7 ft (5.7 m) Long

Figure 1b - Sketch of SWATH 6D Strut Configuration

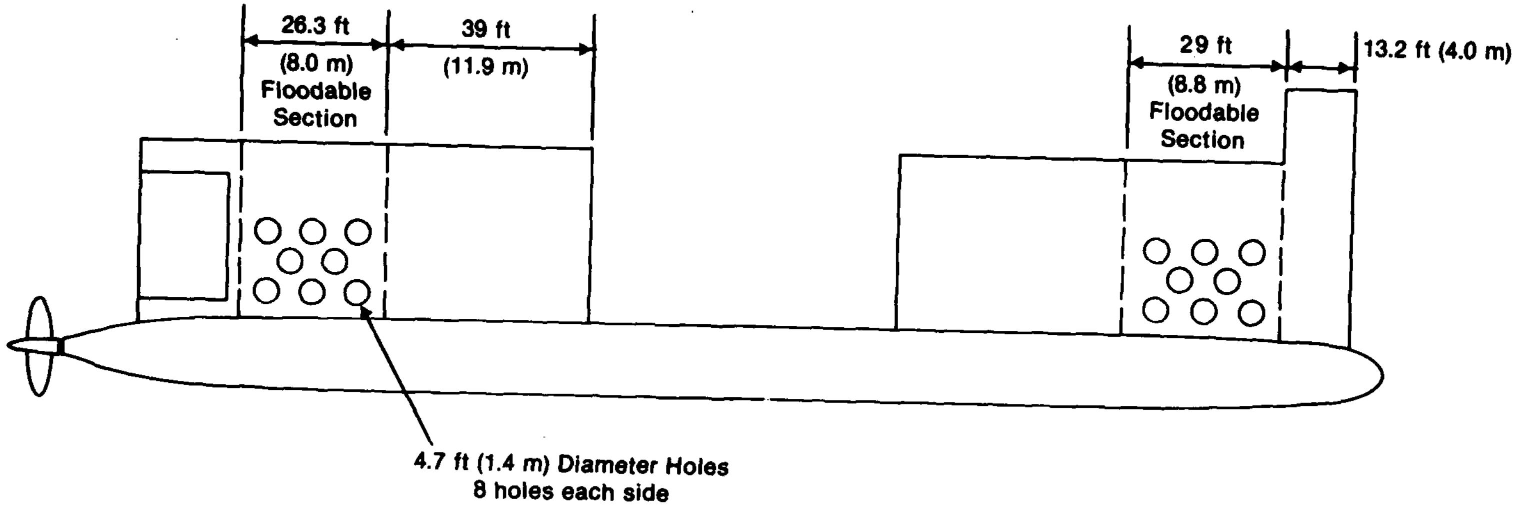
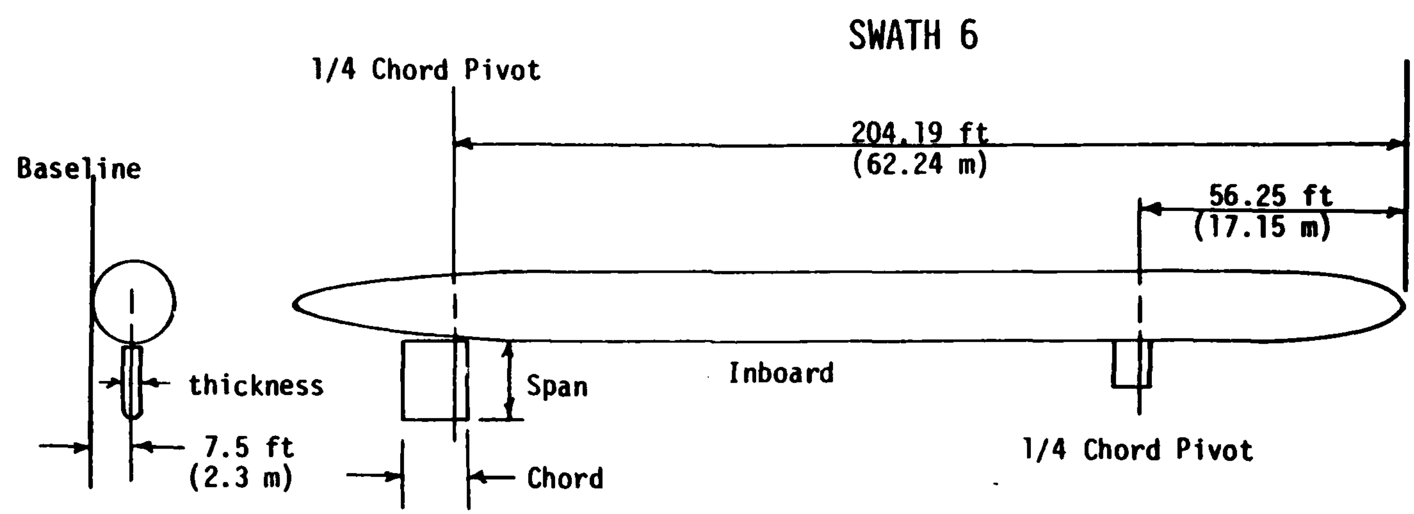


Figure 1c - Sketch of SWATH 6D Floodable Strut Section Locations



Fin Section NACA 64-015

Configuration	AFT FIN			FORWARD FIN		
	Chord	Span	Thickness (max)	Chord	Span	Thickness (max)
6A & 6D	14.7 ft (4.48m)	17.6 ft (5.36m)	2.20 ft (0.67m)	8.50 ft (2.59m)	10.2 ft (3.11m)	1.27 ft (0.39m)
6B	12.3 ft (3.73m)	14.7 ft (4.48m)	1.83 ft (0.56m)	7.10 ft (2.16m)	8.50 ft (2.59m)	1.06 ft (0.32m)
6C	12.3 ft (3.73m)	14.7 ft (4.48m)	1.83 ft (0.56m)	7.10 ft (2.16m)	8.50 ft (2.59m)	1.06 ft (0.32m)

Figure 2 - Fin Size, Shape and Location on SWATH 6

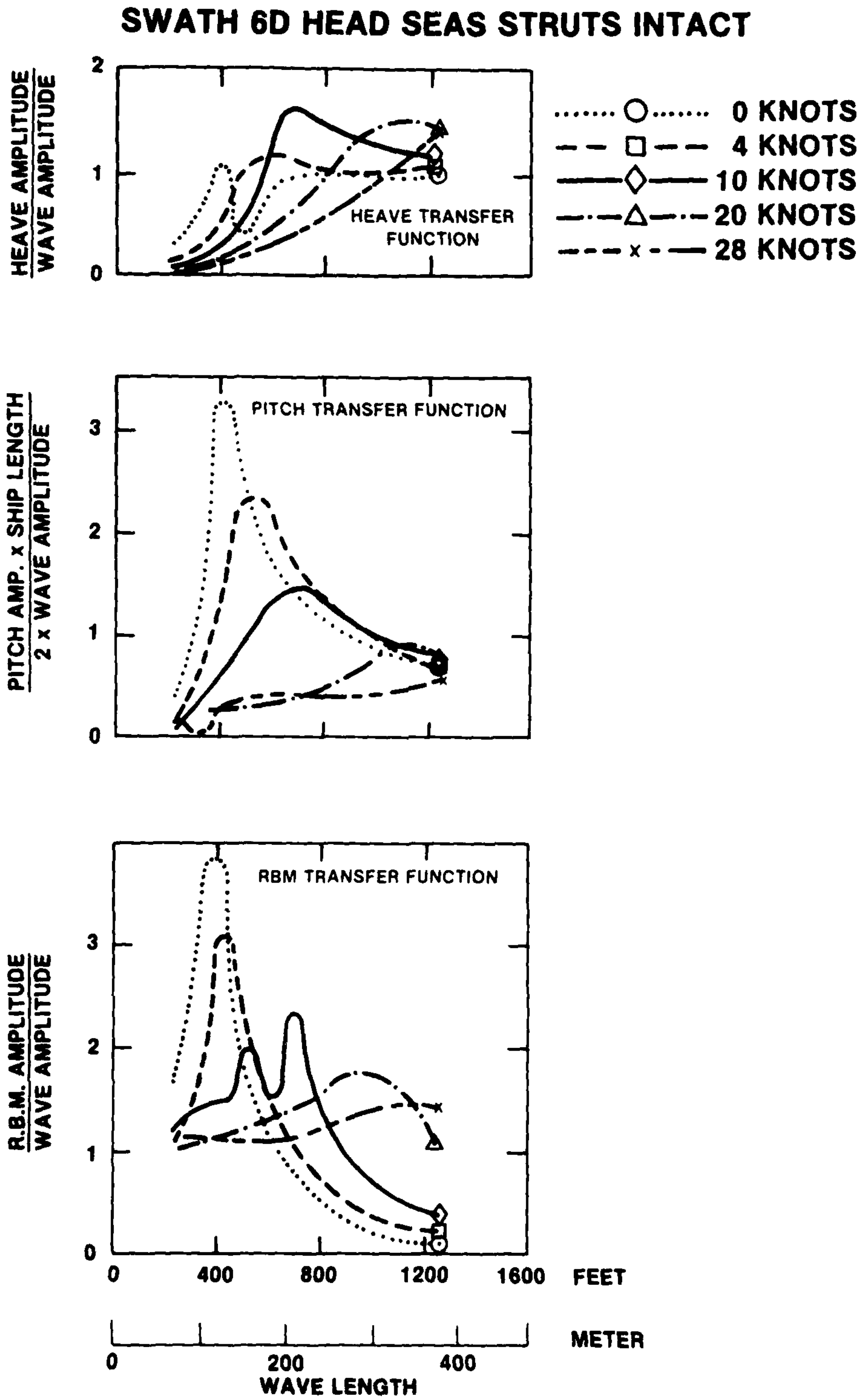


Figure 3 - Motion Transfer Functions in Regular Head Seas for SWATH 6D with Struts Intact

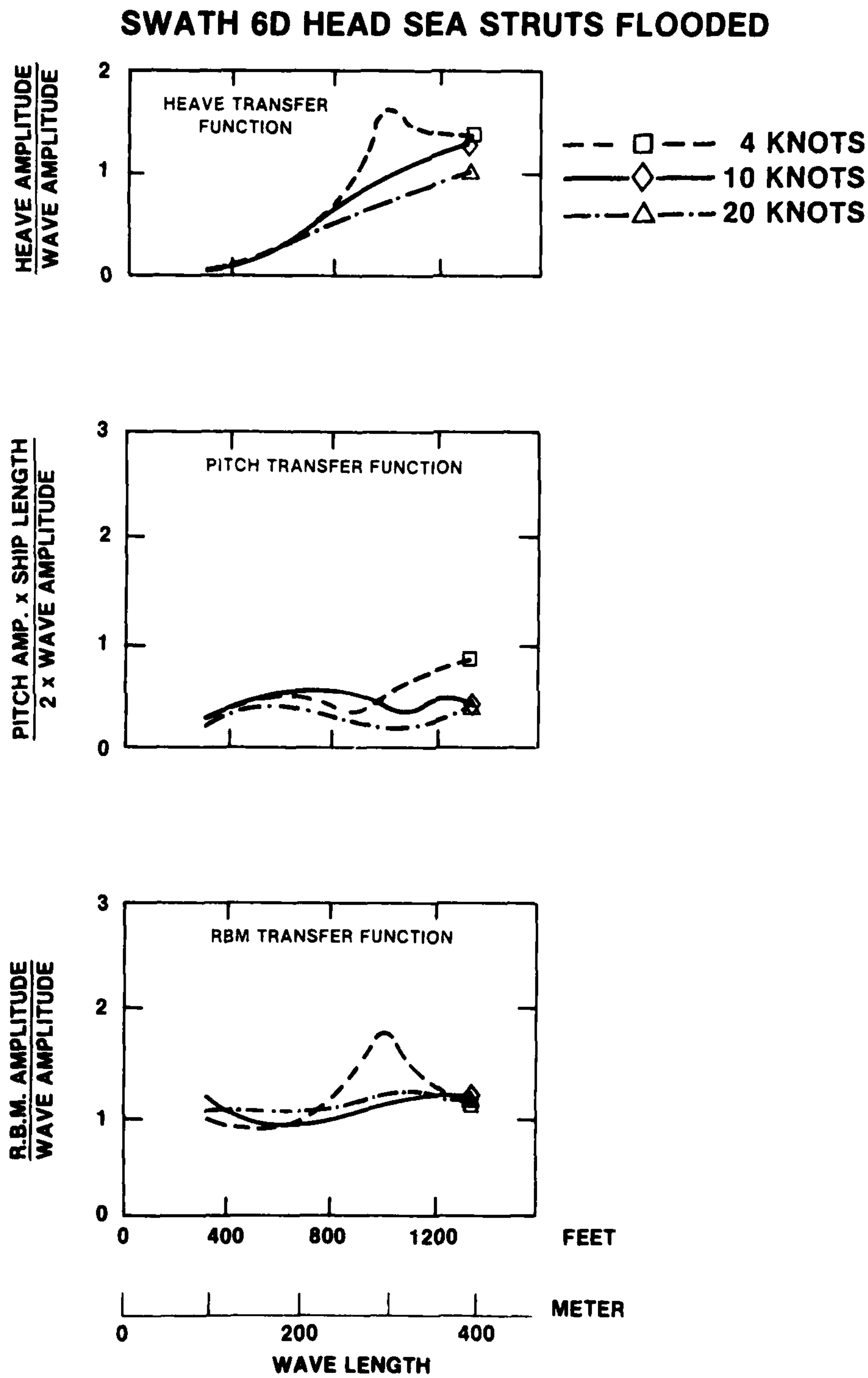


Figure 4 - Motion Transfer Functions in Regular Head Seas for SWATH 6D with Struts Flooded

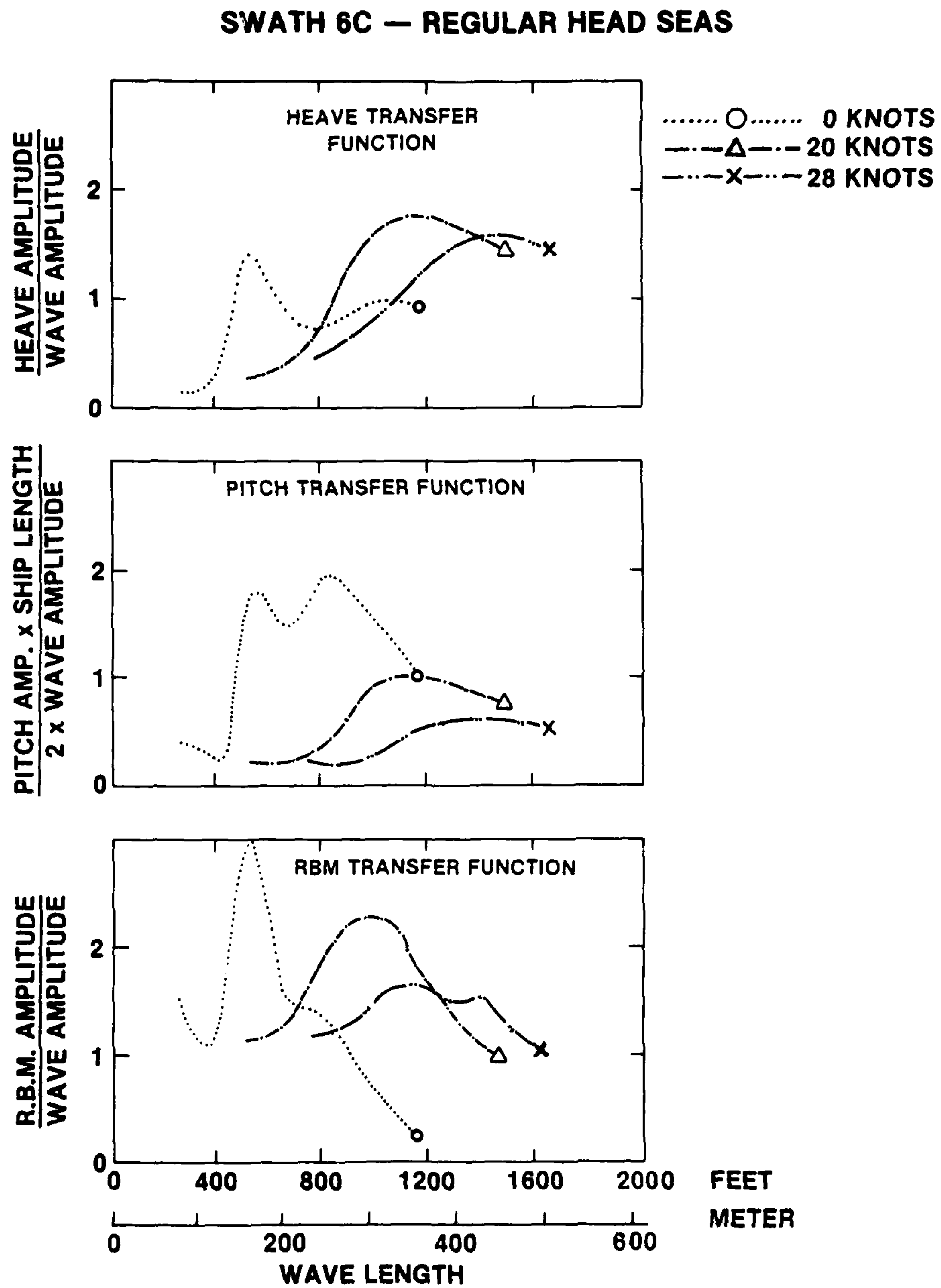


Figure 5 - Motion Transfer Functions in Regular Head Seas for SWATH 6C

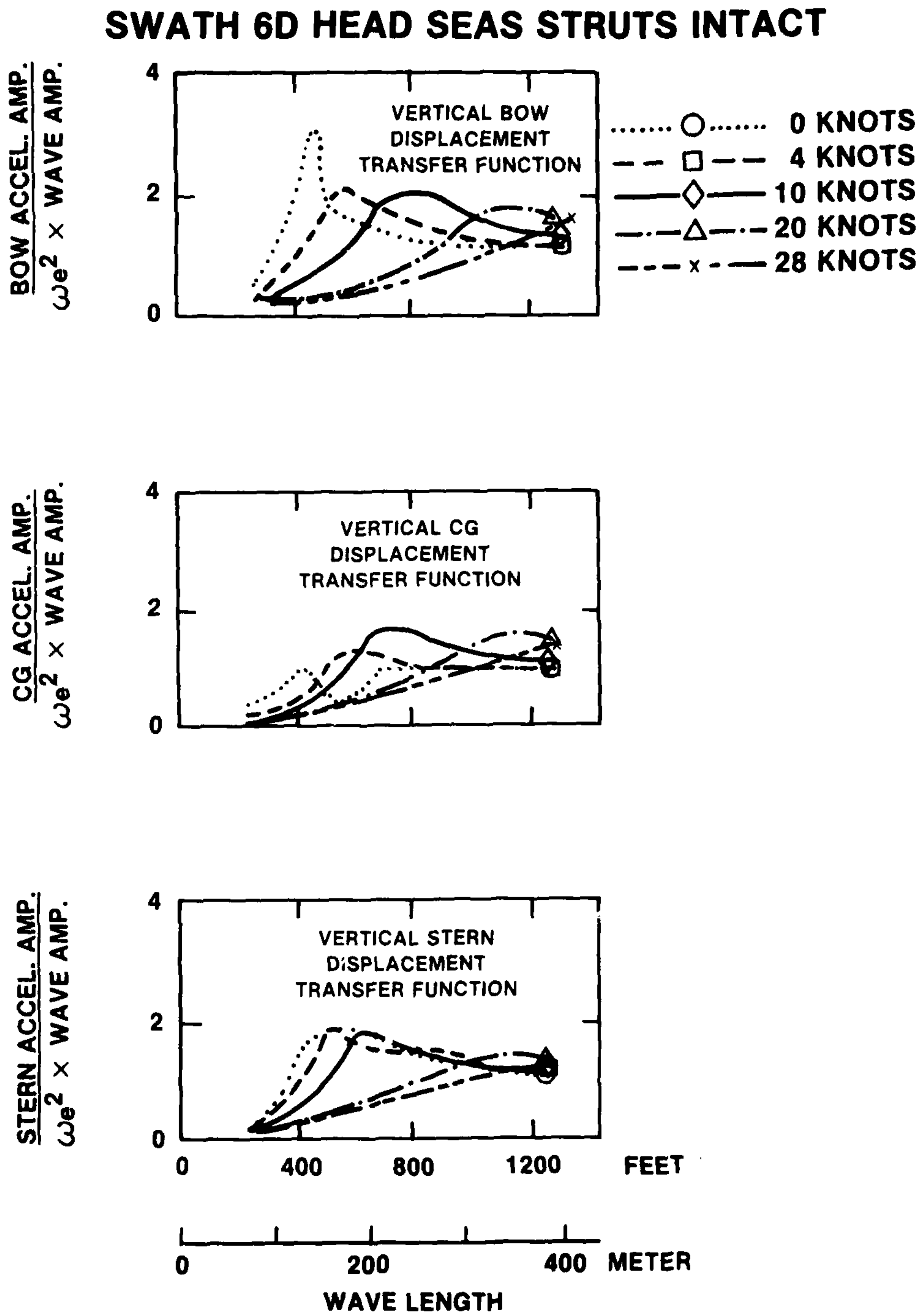


Figure 6 - Vertical Displacement Transfer Functions in Regular Head Seas for SWATH 6D with Struts Intact

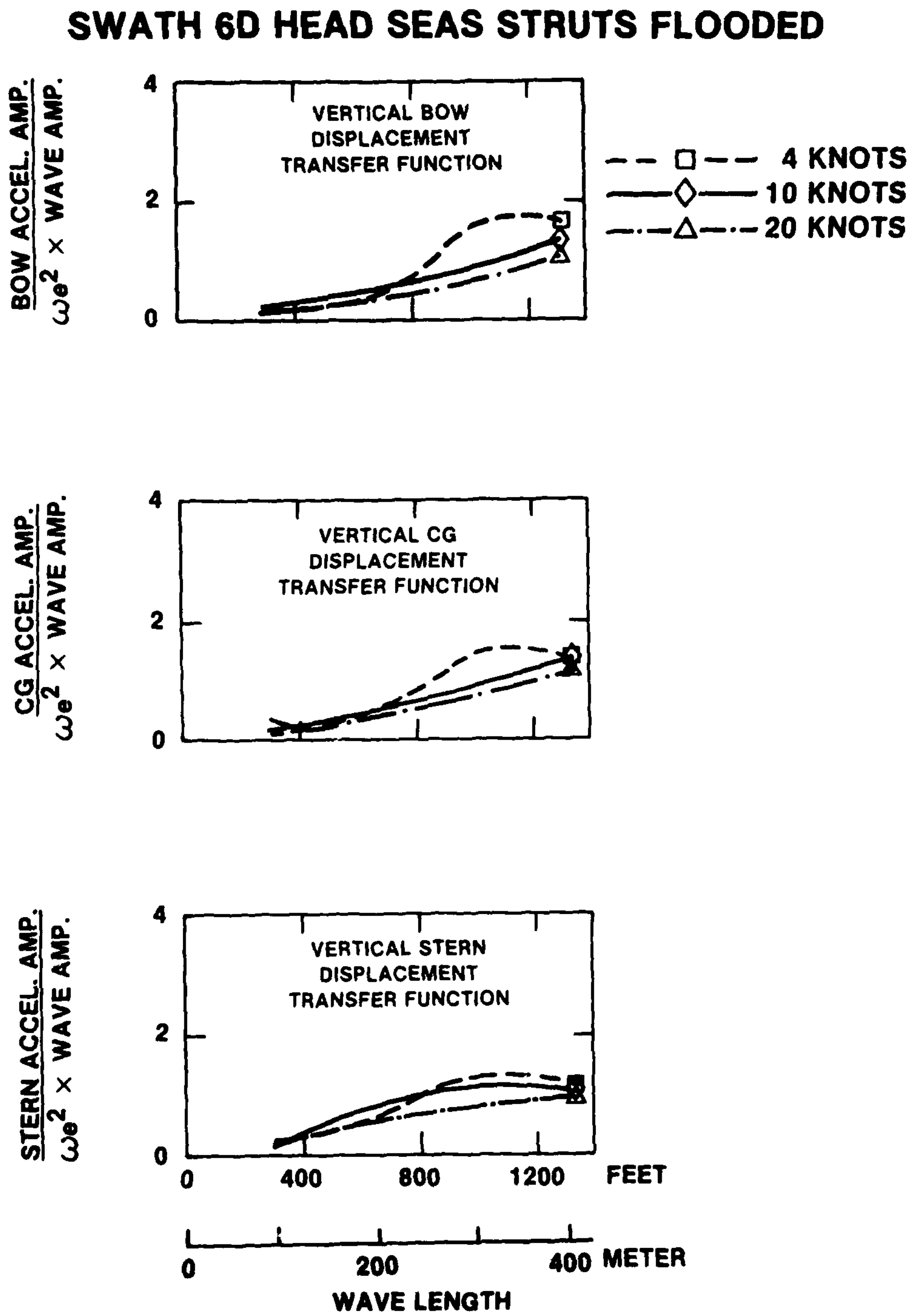


Figure 7 - Vertical Displacement Transfer Functions in Regular Head Seas for SWATH 6D with Struts Flooded

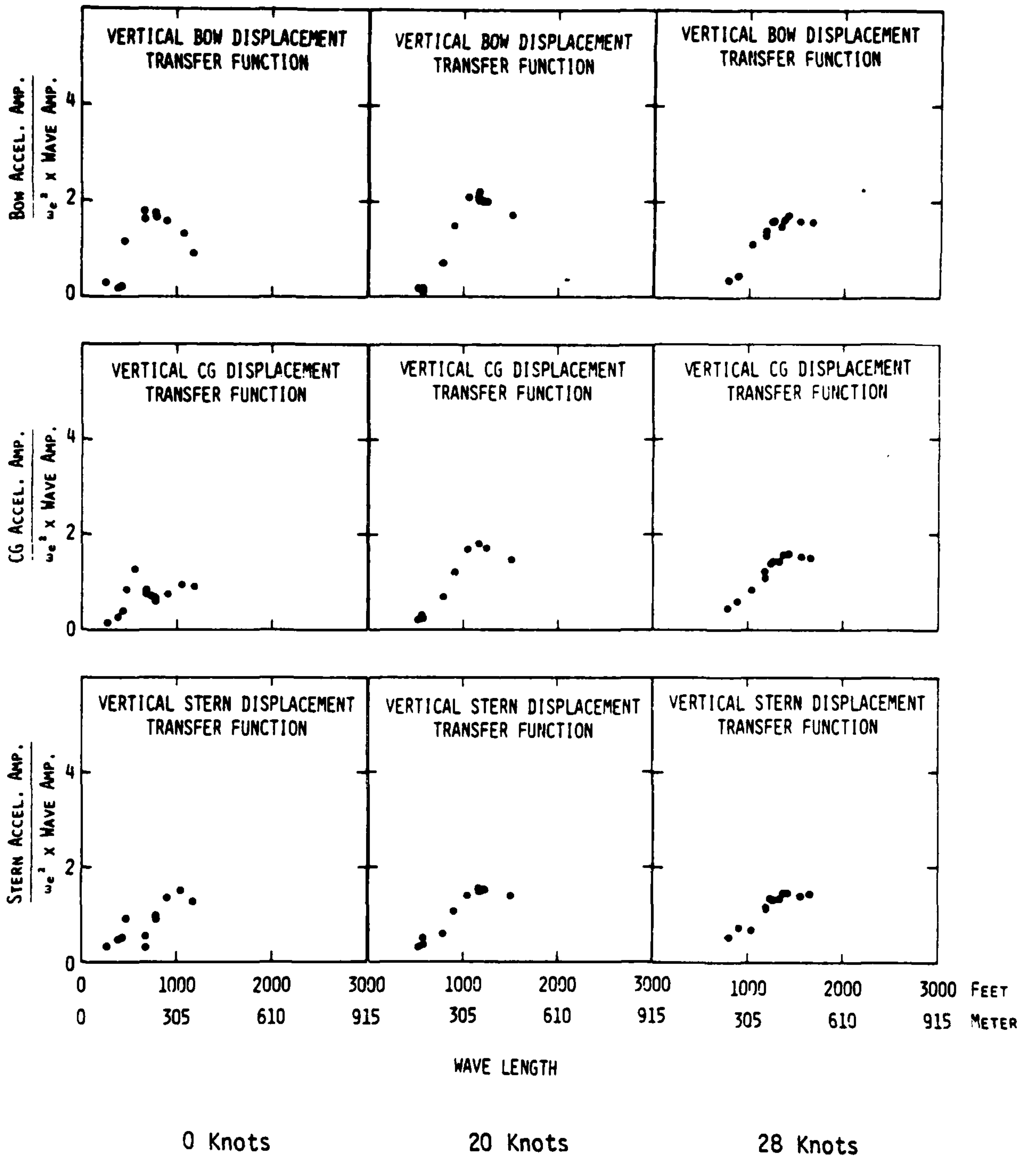


Figure 8 - Vertical Displacement Transfer Functions in Regular Head Seas for SWATH 6C

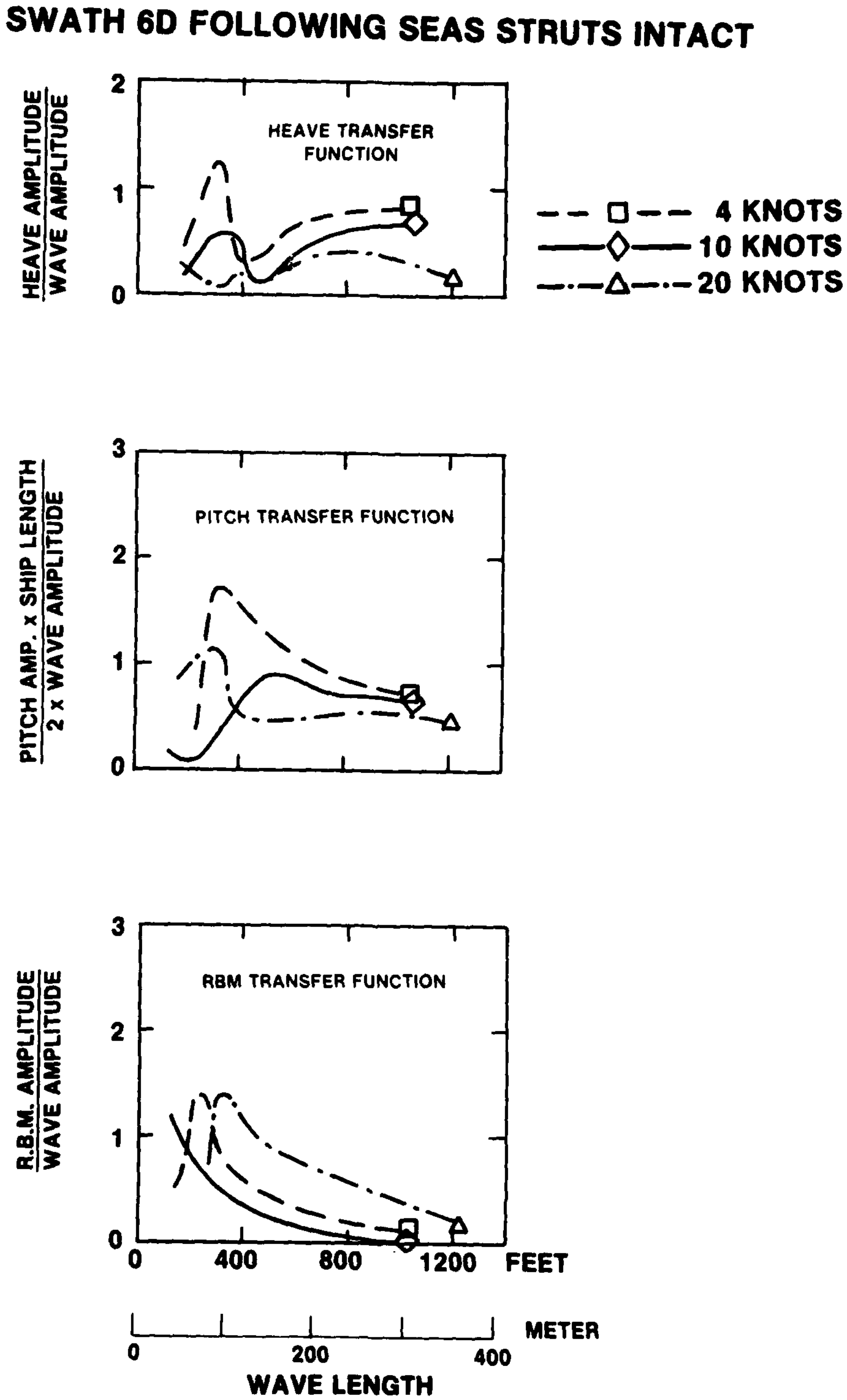


Figure 9 - Motion Transfer Functions in Regular Following Seas for SWATH 6D with Struts Intact.

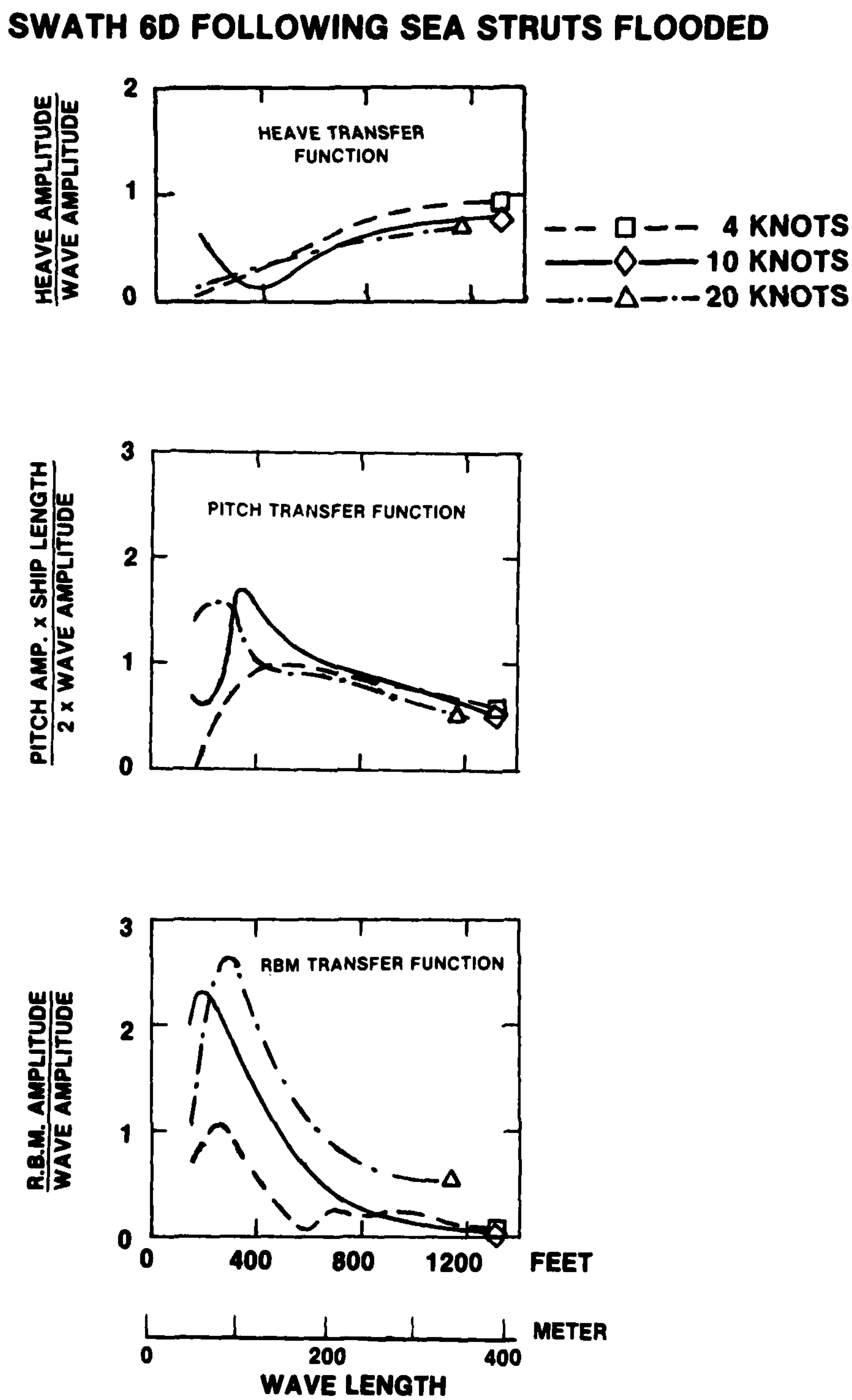


Figure 10 - Motion Transfer Functions in Regular Following Seas for SWATH 6D with Struts Flooded.

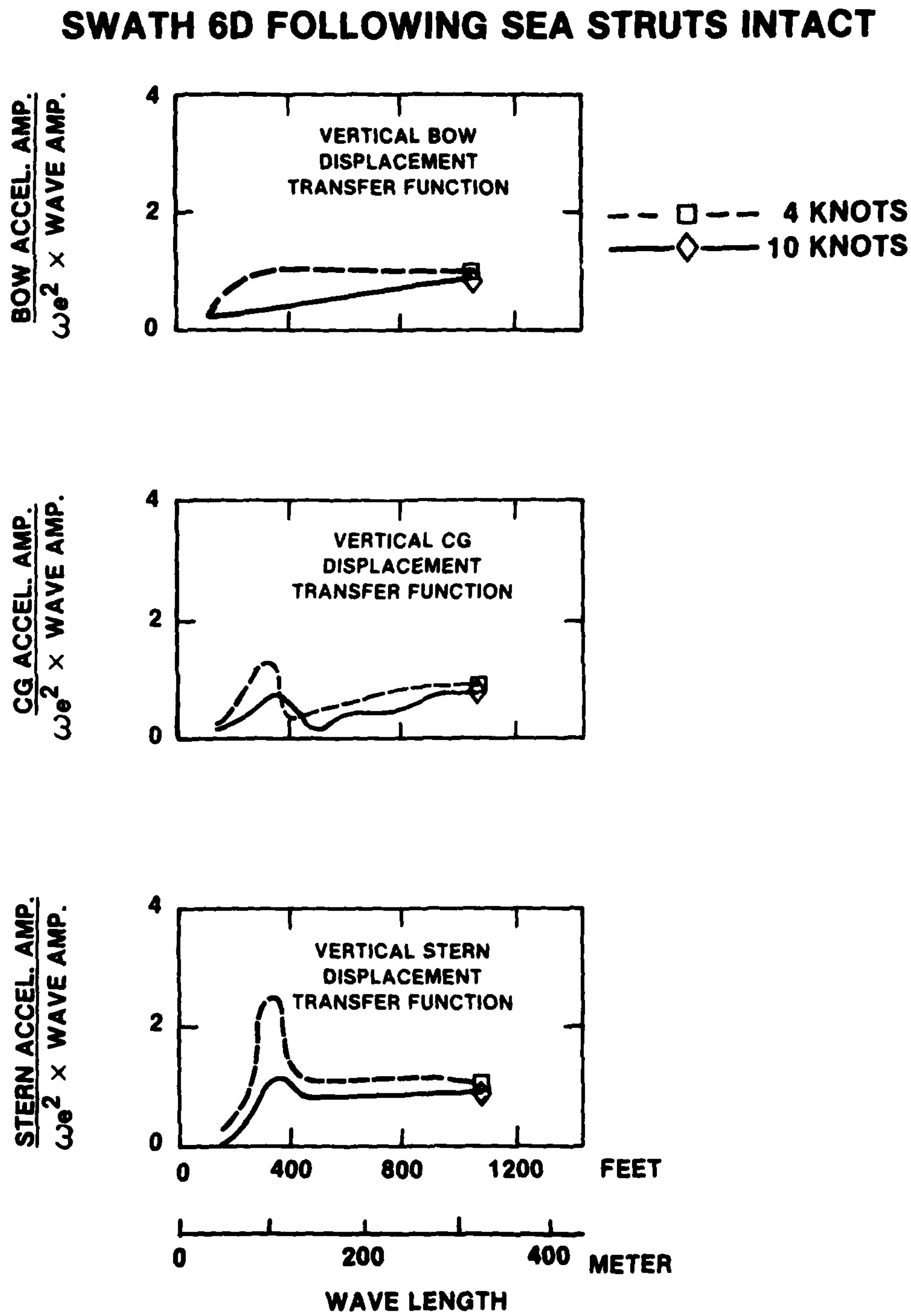


Figure 11 - Vertical Displacement Transfer Functions in Regular Following Seas for SWATH 6D with Struts Intact

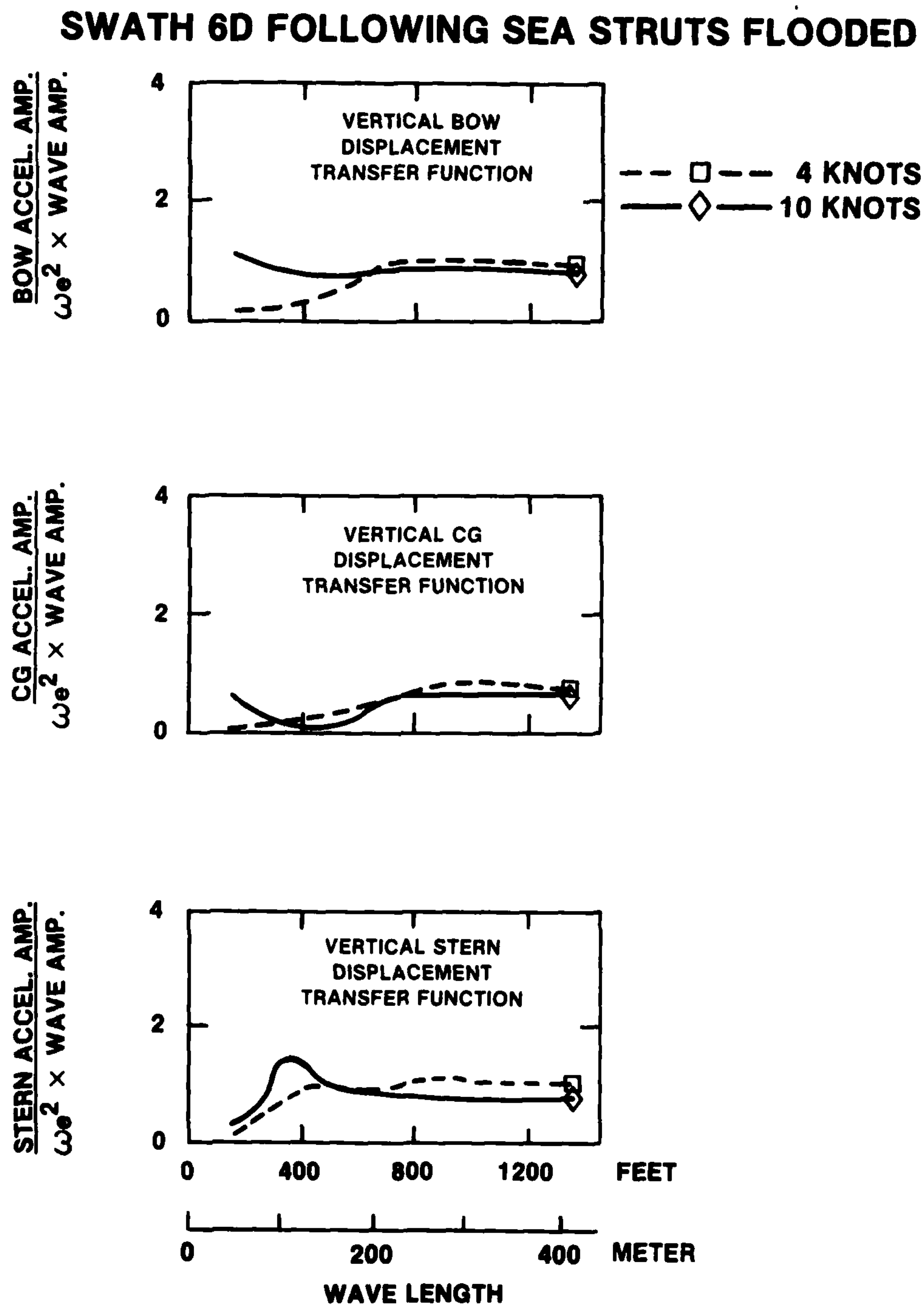


Figure 12 - Vertical Displacement Transfer Functions in Regular Following Seas for SWATH 6D with Struts Flooded

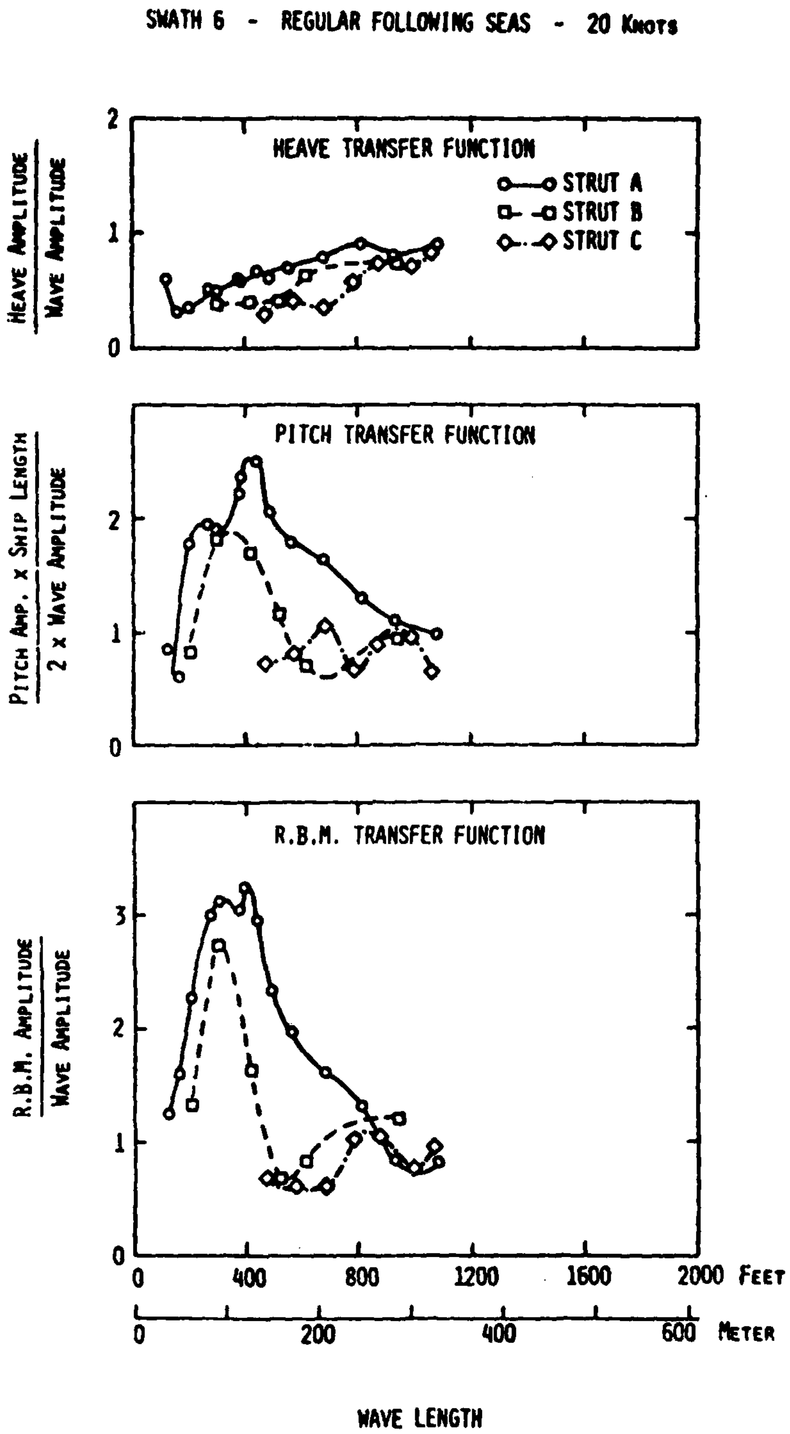


Figure 13 - Motion Transfer Functions in Regular Following Seas for SWATH 6 - 20 Knots.

TABLE 1 - SWATH 6 Craft Particulars

PARTICULAR	UNIT OF MEASURE	STRUT 6A	STRUT 6B	STRUT 6C
Length Overall (LOA)	Feet (Meter)	—	240.0(73.15)	—
Length at the Waterline (LWL)	Feet (Meter)	172.3(52.50)	208.0(63.40)	197.5(60.20)
Beam (Lower Hull)	Feet (Meter)	—	15.0(4.57)	—
Strut Thickness (maximum)	Feet (Meter)	7.25(2.21)	6.00(1.83)	8.47(2.58)
Midship Maximum Breadth (Bridging Structure or at Lower Hull)	Feet (Meter)	—	90.0(27.43)	—
Distance Between Centerlines	Feet (Meter)	—	75.0(22.86)	—
Draft	Feet (Meter)	—	26.67(8.13)	—
Displacement	Long Ton (Metric Ton)	—	2900(2946)	—
Longitudinal CG Aft of Lower Hull Nose	Feet (Meter)	116.3(35.45)	115.3(35.14)	113.9(34.72)
Vertical Center of Gravity ($\overline{KG}$)	Feet (Meter)	—	34.0(10.36)	—
Longitudinal $\overline{GM}$ (Design)	Feet (Meter)	20.0(6.10)	38.0(11.58)	45.0(13.72)
Transverse $\overline{GM}$	Feet (Meter)	11.06(3.37)	10.60(3.23)	10.94(3.33)
Longitudinal Radius of Gyration / LOA	—	0.233	0.245	0.242
Transverse Radius of Gyration / Centerline Hull Spacing	—	0.528	0.530	0.519
Bridging Structure Clearance	Feet (Meter)	—	20.0(6.10)	—
Deck Height Above Baseline	Feet (Meter)	—	60.67(18.49)	—
C_{wp} Strut	—	0.85	0.85	0.68
C_p Lower Hull	—	—	0.85	—

TABLE 1 - Continued

PARTICULAR	UNIT OF MEASURE	6D STRUTS INTACT	6D STRUTS FLOODED
Length Overall (LOA)	Feet (Meter)	240.0 (73.15)	
Length at the Waterline (LWL)	Feet (Meter)	223.2 (68.03)	
Beam (Lower Hull)	Feet (Meter)	15.0 (4.57)	
Strut Thickness (Maximum)	Feet (Meter)	10.16 (3.1)	
Midship Maximum Breadth (Bridging Structure or at Lower Hull)	Feet (Meter)	103.0 (31.4)	
Distance Between Centerlines	Feet (Meter)	88.0 (26.8)	
Draft	Feet (Meter)	26.67 (8.13)	34.45 (10.5)
Displacement	Long Ton (Metric Ton)	2900 (2946)	*
Longitudinal CG Aft of Lower Hull Nose	Feet (Meter)	118.3 (36.1)	
Vertical Center of Gravity ($\overline{KG}$)	Feet (Meter)	29.5 (9.0)	
Longitudinal $\overline{GM}$ (Design)	Feet (Meter)	86.7 (26.4)	—
Transverse $\overline{GM}$	Feet (Meter)	15.5 (4.7)	—
Longitudinal Radius of Gyration / LOA	—	0.260	—
Transverse Radius of Gyration / Centerline Hull Spacing	—	0.511	—
Bridging Structure Clearance	Feet (Meter)	20.0 (6.10)	12.2 (3.72)
Deck Height Above Baseline	Feet (Meter)	60.67 (18.49)	
C_{wp} Strut	—	0.68	0.42
C_p Lower Hull	—	0.85	

* Loss of 203 Long Tons (206 Metric Tons) buoyancy

TABLE 2

Transducer Locations on SWATH 6D

TRANSDUCER	AFT OF LOWER HULL NOSE FEET (METER)
Heave	@LCG
Pitch	168.0 (51.2)
Roll	168.0 (51.2)
Relative Bow Motion	9.4 (2.9)
Surge	219.6 (66.6)
Sway	@LCG
Yaw	168.0 (51.2)
Vertical Bow Acceleration	39.0 (11.9)
Vertical LCG Acceleration	@LCG
Vertical Stern Acceleration	219.6 (66.6)

TABLE 3

SWATH 6D Regular Wave Experiment Matrix

HEADING	SPEED (KNOTS)	STRUTS INTACT	STRUTS FLOODED
Head Sea (180°)	0	X	
	4	X	X
	10	X	X
	20	X	X
	28	X	
Following Sea (0°)	4	X	X
	10	X	X
	20	X	X

TABLE 4

SWATH 6D Natural Periods in Calm Water, Seconds Full Scale

SPEED (KNOTS)	STRUTS INTACT			STRUTS FLOODED		
	PITCH	HEAVE	ROLL	PITCH	HEAVE	ROLL
0	9.01	9.49	12.81	13.85	12.52	20.49
4	8.68	9.49	12.71			
10	9.01	9.25	12.95			
20	9.96	9.72	14.70			

TABLE 5

Definition of SWATH 6 Transfer Functions

TRANSFER FUNCTION	NONDIMENSIONALIZATION
Heave	$\frac{\text{Heave Amplitude (m)}}{\text{Wave Amplitude (m)}}$
Relative Bow Motion (RBM)	$\frac{\text{Relative Bow Motion Amplitude (m)}}{\text{Wave Amplitude (m)}}$
Vertical Displacement	$\frac{\text{Vertical Acceleration Amplitude (g)} \times 9.8\ \text{m/sec}^2/\text{g}}{\omega_e^2(\text{sec}^{-2}) \times \text{Wave Amplitude (m)}}$
Pitch	$\frac{\text{Pitch Amplitude (rad)} \times \text{Ship Length (m)}}{2 \times \text{Wave Amplitude (m)}}$

Ship Length = 240.0 ft (73.15 m)

DTNSRDC ISSUES THREE TYPES OF REPORTS

1. DTNSRDC REPORTS, A FORMAL SERIES, CONTAIN INFORMATION OF PERMANENT TECHNICAL VALUE. THEY CARRY A CONSECUTIVE NUMERICAL IDENTIFICATION REGARDLESS OF THEIR CLASSIFICATION OR THE ORIGINATING DEPARTMENT.

2. DEPARTMENTAL REPORTS, A SEMIFORMAL SERIES, CONTAIN INFORMATION OF A PRELIMINARY, TEMPORARY, OR PROPRIETARY NATURE OR OF LIMITED INTEREST OR SIGNIFICANCE. THEY CARRY A DEPARTMENTAL ALPHANUMERICAL IDENTIFICATION.

3. TECHNICAL MEMORANDA, AN INFORMAL SERIES, CONTAIN TECHNICAL DOCUMENTATION OF LIMITED USE AND INTEREST. THEY ARE PRIMARILY WORKING PAPERS INTENDED FOR INTERNAL USE. THEY CARRY AN IDENTIFYING NUMBER WHICH INDICATES THEIR TYPE AND THE NUMERICAL CODE OF THE ORIGINATING DEPARTMENT. ANY DISTRIBUTION OUTSIDE DTNSRDC MUST BE APPROVED BY THE HEAD OF THE ORIGINATING DEPARTMENT ON A CASE-BY-CASE BASIS.